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A Local Policy-Oriented Air Cargo Forecasting Model

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ABSTRACT

THERE IS A GROWING dissatisfaction with the use of top-down aggregate forecasting models for local air-traffic planning. Growing land and air-side congestion, proliferating routes, and the general uncertainty associated with a newly deregulated industry require policy-oriented forecasting models calibrated bottom-up, sensitive to local conditions, and hence reliant on local airport data. Such models must fulfill the following three conditions:

1. Their development (specification and calibration) must be attained under strict constraints of both budget and time.
2. They must allow for forecasts at relatively disaggregated levels of type of service.
3. They must embody a structural format that allows local planning authorities to maintain, update, and apply the model to both economic and policy-priority changes over time in a straightforward and inexpensive manner.

This paper describes such a model developed by Charles River Associates for Logan Airport (CRA, 1979).

INTRODUCTION

Accurate forecasts of air cargo activity at the local airport level are crucial for many uses. In particular, development planning by local authorities calls for good estimates of future trends to fulfill federal requirements such as those needed for Environmental Impact Statements, and for the allocation of scarce land and other resources to their most efficient uses as new contracts and leases periodically come up for renewal. This paper describes the development of an operational forecasting model for the express purpose of facilitating a medium- to long-range (5-20 year) land-use planning project at Logan International Airport in Boston.

Structural econometric models such as this are generally not available to local planners. Typically such planners must rely on forecasts derived by the FAA by applying fixed fractional coefficients to topdown national traffic forecasts.[1] These forecasts at the individual airport level tend to be quite poor, and the FAA is currently attempting to deemphasize the top-down approach, and to place more emphasis on forecasts like this study that rely on local data. The model described in the following sections was explicitly designed so that both its design and future maintenance and operation should be well within the resources and capabilities typically available to local airport managements.

STUDY DESIGN

Data Used

Air cargo data for individual airports are available at both the national and the local level. For a study such as ours, the use of local data derived from national sources (such as the CAB Service-Segment data) has the a priori drawback of relying on a secondary source (since the data had to be relayed from the local level in the first place). Its use, therefore, would be justified only for reasons of quality (e.g., disaggregation levels), quantity (e.g., data not otherwise available), or cost advantage.

In this case it was determined that for most purposes data from the Aviation Department of the Massachusetts Port Authority was available and was generally superior in scope to that available from alternative sources.

The data actually used in the study were:

- **Massport Aviation Department Figures.** As noted, this constituted the bulk of the data set. It included tonnages loaded and unloaded respectively, of freight and express, and of mail. Domestic and International figures were available for air-carriers and for noncertified (commuters, air taxis, and charters) carriers respectively.
- **International Civil Aviation Organization (ICAO) Figures.** Worksheets prepared for the ICAO provided distributions of cargo by type of plane (lowerhold versus specialized freighter) on a monthly basis.
- **FAA Hub Figures.** Air cargo forecasts prepared by the FAA for eight hubs (not including Boston)

*Charles River Associates.

provided background data on a national and regional level for various factors such as expected national trends for cargo load factors for the next 20 years.

- **CAB Service Segment Cargo Data.** This source was used to obtain cargo lift capacity for individual flights and airplane type.

The Estimated Equations

The following air cargo demand forecasting equations were estimated on annual Logan observations over the period 1965-1978 using the ordinary least squares regression technique, except where an autocorrelation first-difference correction factor ρ is presented. In the cases a generalized least square (with search) algorithm was used. The figures in parentheses under the co-efficients are t-statistics.

The exogenous variables are enplaned plus deplaned freight per year, in thousands of pounds. The explanatory variables are New England income, an economic activity measure, and average national freight revenue per ton, a rate measure.

Domestic Freight and Express

$$\mathrm{LOG(DOMTCAR)} = \underset{(27.4)}{7.036} + \underset{(7.19)}{0.676}\ \mathrm{LOG}\ (\mathrm{ETOTNO}_t - \underset{(2.70)}{0.920}\ \mathrm{LOG(RPTOTC)}_t - \underset{(2.86)}{0.757}\ \mathrm{LOG}\ (\mathrm{RPTOTC})_{t-1} \qquad \bar{R}^2 = 0.975,\ DW = 2.33 \qquad (1)$$

Domestic Freight and Express — Certified Carriers

$$\mathrm{LOG(DOMCAR)}_t = \underset{(28.0)}{7.340} + \underset{(5.78)}{0.556}\ \mathrm{LOG}\ (\mathrm{ETOTNO})_t - \underset{(2.88)}{1.002}\ \mathrm{LOG}\ (\mathrm{RPTOTC})_t - \underset{(2.74)}{0.741}\ \mathrm{LOG}\ (\mathrm{RPTOTC})_{t-1} \qquad \bar{R}^2 = 0.971,\ DW = 2.32 \qquad (2)$$

Domestic Mail

$$\mathrm{LOG(DOMMAL)}_t = \underset{(2.60)}{2.026} + \underset{(0.1)}{0.006}\ \mathrm{LOG}\ (\mathrm{ETOTNO})_t + \underset{(7.46)}{0.821}\ \mathrm{LOG}\ (\mathrm{DOMMAL})_{t-1} \qquad \bar{R}^2 = 0.955,\ DW = 1.57 \qquad (3)$$

International Freight and Express

$$\mathrm{INTCAR}_t = \underset{(1.65)}{1.24} - \underset{(3.65)}{948029}\ (\mathrm{RPINTT})_t + \underset{(2.47)}{2534.05}\ (\mathrm{ETOTNO})_t \qquad \bar{R}^2 = 0.899,\ DW = 2.07,\ \rho = 0.100 \qquad (4)$$

International Mail

$$\mathrm{LOG}\ (\mathrm{INTMAL})_t = \underset{(0.38)}{1.45} + \underset{(2.04)}{1.681}\ \mathrm{LOG}\ (\mathrm{ETOTNO})_t + \underset{(0.78)}{0.152}\ \mathrm{LOG}\ (\mathrm{INTMAL})_{t-1} \qquad \bar{R}^2 = 0.978,\ DW = 1.95,\ \rho = 0.875 \qquad (5)$$

where:

DOMTCAR = domestic freight (including express in 000 lbs.);
DOMCAR = domestic freight carried in certificated carriers (000 lbs.);
DOMMAL = domestic mail (000 lbs.);

INTCAR = international freight (000 lbs.);
INTMAL = international mail (000 lbs.);
ETOTNO = total earnings in New England (millions of 1967 dollars);
RPTOTC = average freight revenue per ton-mile (¢/ton-mile) — total international carriers divided by the Consumer Price Index (1967=100).
RPINTT = average freight revenue per ton-mile (¢/ton-mile) for certificated (domestic) divided by the Consumer Price Index (1967=100); and

The income and price elasticities of the several cargo categories estimated are presented in Table 1, along with comparable elasticities from several other selected studies.

TABLE 1

COMPARISON OF PRICE AND INCOME ELASTICITIES IN SELECTED STUDIES

	Elasticities	
Present Study	**Price**	**Income**
Domestic Freight and Express — Total	−1.68	0.68
Domestic Freight and Express — Certificated Carrier	−1.74	0.56
International Freight and Express (at the average)	−2.89	1.62
Other Studies		
Boeing[1]	−2.05	2.73
Boeing[2]	−1.04	1.13
Boeing[3]	−0.8 to −1.4	0.06 to 3.47

1 West Bound (Europe-U.S.) air-tons. G. Sletmo, "Air Freight Forecasting and Pricing," Logistics and Transportation Review 2, 1 (1974), p. 8.
2 Hong Kong-U.S. Sletmo, p. 9.
3 Summary of results. Sletmo, p. 15.

Source: Data for Logan in CRA (1979). Data for other studies come from G. Sletmo, "Air Freight Forwarding and Pricing," *Logistics and Transportation Review* 2, 1 (1974), pp. 7-29.

THE SPLIT RATIOS

Enplanement-Deplanement Ratio

Since the econometric model (Equations 1 to 5 above) provides a basis for the forecast of total tonnages, the division of the respective subcategory totals by cargo in and cargo out must be determined separately. Logan Airport tends to be a net exporter in most categories of cargo. The ratio of enplaned to deplaned domestic freight and express ranged from 1.10 in 1978 to 1.40 in 1961. Domestic mail ranged from .916 in 1970 to 1.14 in 1978. Total international cargo (including mail) ranged from .772 in 1970 to 2.16 in 1965. An examination of these figures led us to use the following ratios of enplaned to deplaned:

- Domestic cargo: 1.2
- Domestic mail: 1.0
- International total: 1.5.

These are the ratios which were applied to the forecast totals to develop the enplaned and deplaned figures for the projections to the year 2000.

The Proportion of Tonnage in All-Cargo Freighter

The handling of cargo to and from all-cargo freighters may require special consideration when designing new facilities for various reasons (e.g., different time schedule, different container configuration). These figures are derived as follows. Actual cargo splits for Logan (domestic and international) were obtained for 1978 by applying the all-freighter/total tonnage ratio specific to Logan enplanements and deplanements for 1978 obtained from ICAO to the total freight and express totals from the Massport Aviation Section's figures.

In order to project the lowerhold/freighter split, the ratio of all-freighter tonnage to all tonnage was obtained for the year 1975 for several airports from FAA sources. The same sources presented FAA projections of these ratios to the year 1990. The average ratios in the two years (respectively) were calculated for those airports which had substantial international cargo in 1975 (Chicago, Los Angeles, Miami, and Philadelphia). Then the rate of change in this ratio projected by the FAA from 1975 to 1990 was obtained and applied to the actual Logan situation in 1978. Thus, this projection of the lowerhold/freighter split is in concurrence with the FAA projections. A gradual decline was forecast over the period in the proportion of air-cargo tonnage that will be carried in freighters over the next 20 years.

THE RESULTS

This section presents the forecasts derived in this study. The forecast is a baseline projection containing the most likely pattern of future air cargo demand. The forecast assumes that no dramatic changes will occur in air freight technology, in the structure of the industry, in the nature of supply constraints facing Logan operations or in the political environment in which the industry operates. An example of such a change in the last category would be an overt decision by the government to ration fuel supplies to the airline industry so as to discontinue all-cargo freighter operations. The likely effects of scenarios involving changes in fuel availability and night restrictions were also examined, but are not presented here.

Income Changes Assumptions

During the forecast time frame, the region's income — measured by total earnings — will continue to grow. However, this rate of growth is expected to slow because of continuing declines in the growth of population (as a result of migration and fertility factors) and an apparent decline in measured secular productivity growth related to the growth of the service sector, an increase in concern for environmental and safety issues, and an exhaustion of potential gains from rural-urban migration.

Inflation-adjusted total earnings in the New England region grew at an average annual rate of 4.2 percent during the 1960s. From 1970-1978 the growth rate slowed to an annual rate of 3.2 percent. From 1975 to 1978, real personal income in New England grew at an average annual rate of 4.36 percent as the region recovered from the recession.

In our baseline scenario, we accept the BEA growth projections for several reasons though they are higher than the NPA and Wharton projections for this region. The BEA projections are close to the baseline growth rate of 3.3 percent from 1980-1990 used by the FAA for the U.S. economy in its latest aviation forecasts (DOT/FAA, 1978, p. 14). For capacity-planning exercises, the costs of underestimating future required capacity are usually higher than the costs of overestimating required capacity. And finally, these forecasts are readily available and are constantly being monitored and revised by the Office of Business Economics.

Price Change Assumptions

During the forecast period, our "best guess" assumes that real rates will decline by an annual average of 2.0 percent from 1978 to 1985, and thereafter will decline at 0.8 percent per annum. This equals an average annual decline of 1.1 percent from 1978 to 2000.[2] These projections are based on the following considerations. During the forecast period airlines are expected to improve their cargo-handling capabilities. New terminals coming on line will incorporate more highly automated handling capabilities than the typical existing facilities. The speed of technological innovations, such as the development of specialized freighters, will be a function of traffic generation and government regulatory developments, and are expected to continue during the forecast period. The combined effects of projected increased load factors, increased containerization, improved terminal technology, economies of scale, and the introduction of new specialized systems were projected by one study to lower total operating costs of carriers in the cargo area by up to 35 percent from 1978 to 2000 (Whitehead, 1978), allowing for a decrease of up to 28 percent in rates (with unchanged airline profit margins). Our baseline scenario accepts these figures as reasonable and consistent with historical experience.

The Forecasts

Table 2 presents the actual cargo experience at Logan International Airport, from 1975 to 1978 and the forecast values for several time horizons beginning in 1978. The figures are in terms of average annual rates of growth.

Table 3 compares the Logan baseline forecast with recent all-U.S. air cargo forecasts prepared by the Federal Aviation Administration (FAA) and Air Transport Association (ATA). The structure of cargo growth projected in

TABLE 2

FORECAST OF AVERAGE ANNUAL GROWTH RATES OF CARGO BY TYPE OF SERVICE: BASELINE SCENARIO (Percent)

Type of Service	1975-1978 (Actual)	1978-1985	1978-1990	1978-1995	1978-2000
Freight and Express					
Domestic					
Commuter	23.6	12.6	10.9	9.9	9.0
Total	4.5	6.0	5.0	4.6	4.3
International					
Total	13.3	6.2	5.1	4.6	4.2
Total	6.5	6.0	5.0	4.6	4.3
Mail					
Total	4.0	2.0	1.7	1.6	1.5
Grand Total	6.0	5.3	4.5	4.1	3.8

Source: Charles River Associates, *Logan International Airport Air-Cargo Forecasts*, prepared for Massachusetts Port Authority (Boston, Mass.: CRA, 1979), Table 4-4.

each forecast is similar, with all three projecting a gradual reduction in air cargo tonnage growth rates toward the end of this century. In the near term, 1978-1985, the growth rates projected for domestic tonnages in all three forecasts are nearly identical. The domestic tonnage growth rate forecast for Logan over 1978-1985 lies between those of the other two studies. All three forecasts also indicate that international cargo activity will grow more rapidly than the domestic sector.

The primary difference between the Logan cargo forecast and the FAA and ATA air cargo forecasts lies in projected growth rates for international cargo. The Logan forecast has a lower projected growth rate in international air cargo tonnages. One reason that we might expect the Logan-international cargo growth rate to lag that of the rest of the country is that the Logan market is already relatively mature due to extremely rapid growth in the 1960s. In fact, a clear slowdown in international air cargo growth rates characteristic of a maturing market is already discernible at Logan. A second reason is that Logan's international cargo traffic is primarily with Europe. The ATA forecasts European traffic to grow more slowly than other international traffic segments (Air Transport Association, 1978). Third, a part of the difference between the Logan forecast and the other two is due to different assumptions about the future course of air cargo rates. The FAA and ATA forecasts incorporate a more rapid reduction in inflation-adjusted cargo rates. A fourth reason for the different forecasts is methodological. The Logan forecast is derived using a structural econometric technique while the FAA and ATA forecasts are based on largely judgmental trend extrapolations. For reasons outlined above, we can expect the structural model to perform better in forecasting air cargo activity.

As noted, the growth rate projected for domestic cargo at Logan is nearly identical to those of the FAA and ATA national projections. Because domestic cargo constitutes 75 percent of all freight and express at Logan Airport, the forecast implies that Logan's share in the national air cargo market should remain roughly constant over the forecast period.

SUMMARY

A model was developed which allows for an efficient development of local air cargo forecasts using data and resources typically available at the local airport level. This model which was applied in an actual land-use context yields good results at a relatively disaggregated level of service, and is readily adaptable to changes in the economic environment facing the region.

FOOTNOTES

1 For a good description of the methodology underlying the FAA forecast see Maio, Wang, and Meltzer (1977).

2 Chamberlain (1979) projected an annual decrease of 0.9 percent in the average revenue per ton-mile over the forecast period.

TABLE 3

AVERAGE ANNUAL RATE OF GROWTH OF ENPLANED TONS[1]— SELECTED FORECASTS
(Percent)

Years:	1978-1985		1978-1990		1978-2000	
Region:	Domestic	International	Domestic	International	Domestic	International
Forecasts:						
Charles River Associates, Logan Baseline Scenario	5.03	6.35	4.23	5.27	3.64	4.45
Federal Aviation Administration, U.S. Air Cargo Traffic 1979-1990 Baseline[2]	4.80	7.79	4.69	7.90	—	—
Air Transport Association[3]	5.36	10.36	5.11	9.74	4.65	9.18

1 Includes Freight, Express, and Mail enplaned tonnages.
2 Includes scheduled and nonscheduled services of all U.S. and foreign flag carriers for exports only.
3 Domestic growth rates reflect the enplaned tonnage growth for scheduled services in fifty states. International growth is computed for scheduled and nonscheduled services of both exports and imports. The enplaned tonnage forecasts for each international region are summed to calculate total international growth rates.

Sources: U.S. Department of Transportation, Federal Aviation Administration, *FAA Aviation Forecasts Fiscal Years 1979-1990*, Washington, D.C., September 1978.
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